ON THE ATMOSPHERE.

BY HARLAND COUTLAS.

Natural Phenomena depending on the Pressure of the Atmosphere.—Snails, periwinkles, limpets, and other univalve shells, adhere firmly to the rocks by the pressure of the air, the fish forming its shell so as accurately to fit the surface of the rock, and then shrinking within it so as to create a vacuum.

Exp't. 1. If we place a limpet adhering to a piece of rock, in the exhausted receiver of an air-pump, we shall presently see it fall by its own weight.

It is owing to the same cause that bivalve shell-fish keep themselves so firmly shut. In this case the shells may be easily separated by grinding a hole, and admitting the air.

To the pressure of the atmosphere is to be attributed the power possessed by the fly and some other animals of walking up the walls, and on the ceilings of rooms, the insect producing a vacuum within its feet. This mechanism was first detected in the Gecko, a kind of lizard found in Java. The rapidity with which the fly forms and destroys these vacuums is interesting, and cannot be rivalled by the utmost efforts of human skill. Spiders not being endowed with this mechanism, walk with difficulty along the walls and ceilings of houses clinging to the asperities on such surfaces, which, failing them, of course, precipitates the insect to the ground. It has been calculated that a fly in travelling six feet creates and destroys 10,000 vacuums. If a fly be deprived of its feet, or of the extremities of its legs, on which the apparatus is situated, though it can walk without apparent difficulty on a horizontal surface, such as a table, it is quite incapable of climbing an upright surface, such as that of a wall, or of walking on the ceiling.

The sucker or stone-lifter used by boys, depends for its operation on the pressure of the atmosphere. It consists of a circular piece of leather, two or three inches in diameter, to the centre of which a piece of string is attached. The leather being soaked in water, and pressed with the hand or foot on the surface of a smooth flat stone, on pulling at the string a vacuum is created in the centre, and hence the stone may be lifted from the ground, although it weighs several pounds.

It is a common thing to see children amuse themselves by sucking a thimble. They place a thimble on their arm, and create a vacuum under it with their mouth, the pressure of the atmosphere fastening the thimble on their arm. The child is amused with the adhesion, and is thus led to repeat the experiment.

The strong cohesion which takes place between two plates of glass when wetted is caused by atmospheric pressure, as is evident from the plates spontaneously separating in the exhausted receiver or artificial vacuum created by the air-pump. In quarries, the powerful adhesion of large flag-stones to each other is well known to the workmen, and the ease with which they separate when winded, or when the air can be got between them.

Exp't. 2. If all the air be expelled from a common bellows, and if the pipe and valve (or clapper) be then closed, on raising the handle, a vacuum is created, and it will be found difficult to separate the boards.

In frosty weather a scantiness of water is experienced in fonntains and springs. This is erroneously accounted for, by supposing that the water freezes in the bowels of the earth. But the most intense frost of a polar winter will not freeze the ground more than two feet in depth, whilst a very moderate frost will consolidate its surface, and render it impervions to the atmosphere. When this happens, the water which was filtering through its surface is all arrested, and kept suspended in the capillary pores of the ground, and the supply of water is thus cut off until a thaw ensues, when the ground again becomes soft and pervious to the atmosphere, the water filtering through its surface, as before, and the scarcity disappearing. This scanty flow of water in springs and wells during frost is, therefore, caused by a deficiency in atmospheric pressure, the air being prevented by the frost from gaining any access to the water in the pores of the ground.

These instances are sufficient to show the important part which the atmosphere performs in the production of many common and very interesting natural phenomena.

Amount of Atmospheric Pressure.—It has been shown that the pressure of the air will support a column of water 34 feet in height, and a column of mercury 30 inches in height, mercury being 13.5 times heavier than water. Now, by the law of fluid pressure, the height of the column of water and mercury supported by the air will be exactly the same whatever be the diameter of the columns. In order to facilitate tho measurement, let the area of the base of each of the columns be one square inch. If, now, both columns be weighed, we shall find the weight of each to be precisely the same, about 15 lbs. It follows, that the weight of a column of air, reaching from the earth's surface to the extreme limits of the atmosphere, and which is one square inch in section, weighs about 15 lbs. This column of air sustains both the columns of mercury and water, and acts as a counterpoise weight to their pressure. The atmosphere, therefore, presses on all bodies with a force of 15 lbs. to the square inch.

From the above facts, it is plain that the weight of the whole atmosphere is equal to that of a covering or sea of mercury 30 inches in depth, enveloping the earth, and the weight of which has been calculated to be equal to the weight of a solid ball of lead, 60 miles in diameter. It is also evident that every square inch of the human body is subjected to a pressure of 15 lbs. But the body of an ordinary sized man exposes a surface of from ten to eleven square feet; therefore, the pressure of the atmosphere on the entiro surface of the human body must be equal to $11 \times 144 \times 15 = 23,760$ lbs., or more than $10\frac{1}{2}$ tons! It is becauso the human body is full of the air which presses on it, that we are not crushed to pieces by this enormous weight, just as a sponge is not crushed by the weight of the

superincumbent water when immersed in the depths of the ocean.

Variation in the Pressure of the Atmosphere.—The pressure of the atmosphere is a variable quantity. This will be evident to any of our readers who will only take the trouble to watch the mercurial column of the barometer for a few days or weeks, when it will be found to vary from 28 to 31 inches in height, indicating, of course, a corresponding change in the weight of the atmosphere. These ordinary variations are found to have a marked effect on nature. When the atmosphere presses heavily, the mercury rises in the barometer, the clouds are borne high, and we have fine weather. When the atmosphere presses lightly, the mercury falls, the clouds descend towards the earth, and we have rain or snow. At such times, the smoke of cities descends into the streets, especially if there is no wind, or forms a closely overhanging canopy of murky clouds above them, and all abroad is a scene of moisture, gloom, and discomfort.

The barometer is an admirable prognosticator of the approach of winds, falling long before the wind rises; hence it is a valuable instrument at sea, apprising the mariner of the approach of storms long before they make their appearance on the horizon, so that he is able, by making a timely preparation, to turn aside their desolating effects. The fall of the mercury, on the rising of the wind, is owing to the lateral velocity of the current of air diminishing its downward pressure.

In the mercurial barometer, the column varies in height from 28 to 31 inches. This range is too small to render the ordinary changes in the atmosphere appreciable, and various contrivances have been resorted to in order to enlarge the range. It must be obvious that the water barometer is too inconvenient for general use on account of its size, it being requisite that the tube should contain a column of water 34 feet in height, in order to act as a counterbalance to the pressure of the atmosphere. There is, however, a water barometer in the hall of the Royal Society in London. The range of this water barometer is upwards of three feet, and it is found to give large and violent undulations long before any change is perceptible in the mercurial column. The water barometer in the Royal Society's rooms, at London, leaps up and down at every breeze, and in its way enables us to see as well as measure the slightest variation in the pressure of the atmosphere.

Height of the Atmosphere.—Various attempts have been made to ascertain the height to which the atmosphere extends all around the earth. These commenced soon after it was discovered by means of the Toricellian tube that air is possessed of gravity or weight. Were the density of the atmosphere every where the same as at the earth's surface, this matter might be easily settled, for in that case it would reach no higher than 26,100 feet, or nearly five miles. This calculation is easily affected, and it involves a knowledge of the following data.

Shortly after the invention of the barometer, it was found that the mercury descended 1-10th of an inch in the tube for every rise of 87 additional feet of elevation above the earth's surface. From this observation the ratio of the specific gravity of a cubic inch of air to that of a cubic inch of mercury may be deduced; 1-10th of an inch of mercury having clearly the same weight as 87 feet or 1,044 inches of air. Consequently, one inch of mercury weighs as much as 10,440 inches of air. Taking, therefore, as the average height of the mercury in the barometer to be 30 inches, it is evident that the height of the ærial column supported by the mercurial column, will be inversely as the ratio of their specific gravities, and we shall have the following proportion: —1 : 10440 : : 30 : 313,200 inches, or 26,100 feet = 5 miles nearly. From this we infer that the column of air supported by the mercurial column would be five miles high, provided its density were the same throughout its entire length.

But, owing to the elasticity of the air, its density is in proportion to the force by which it is compressed, and consequently it is more dense near the earth's surface than in the upper regions of the atmosphere, being pressed by a greater number of superincumbent strata, the atmosphere expanding with the decreasing pressure at every successive elevation; and since no limits can be assigned to the expansion, it is impossible to ascertain precisely how high the air exteuds above the earth.

By experiment, made on refraction and twilight, it has been found that the refractive power of the air ceases at the height of about 45 miles, so that at that elevation there must be either a vacuum or something approximating towards it. The height of the atmosphere is, therefore, estimated at about 45 miles.

It has been calculated, that if a cubic inch of air were taken from the surface of the earth to a height of 500 miles, it would expand itself so as to fill a sphere as large as the orbit of Saturn! Even at a height of 80 miles, the air is so rare as to be imperceptible when subjected to the nicest experiments.

Hence, by taking a flaccid bladder up in a balloon, or to the top of a mountain, the external pressure being lightened, the air in the bladder expands and fills it.

In like manner, on descending into the denser strata of air, near the earth's surface, the pressure of the superincumbent atmosphere overcomes the elastic pressure of the air enclosed in the bladder, and causes it to shrink again to its former dimensions.

If, whilst at the top of a lofty mountain, we cork an empty bottle, and, on arriving in the valley, we go to a vessel containing water, and inverting the bottle, uncork it under the water, a considerable quantity of water will instantly enter the bottle, proving the increased rarity of the air on the top of the mountain.

Effects of Changes in the Density and Pressure of the Atmosphere on the Human Body.—It does not appear that we are much affected by the ordinary changes in atmospheric pressure at the earth's surface. The uneasy and opposite feelings at different states of the barometer, are to be attributed to changes in the moisture, temperature, and electrical state of the atmosphere, than to the mere alteration in the state

of its pressure, the result of its increased or diminished rarity or density. When, however, the pressure of the air is much altered, as in the diving-bell, or at great elevations on mountains or in balloons, the change produces a marked effect on the feelings, and in some cases proves very hurtful.

In the diving-bell the air is much condensed, being influenced not only by the usual atmospheric pressure, but also by the upward pressure, or buoyancy of the water, which is equivalent to the pressure of an additional atmosphere, for every additional 33 feet of depth to which the bell is sunk. The upward pressure of water is equal to its downward pressure, and, therefore, the amount of pressure in the bell at the depth of 33 feet must be doubled, or equivalent to the pressure of a column of water 66 feet high. Hence, on descending into the water in the diving-bell, the condensation of the air in the bell produces painful feelings of pressure on the head, the ears, and about the chest, in some persons; whilst others experience sensations of sprightliness and excitement like gentle intoxication.

Peculiar feelings are also experienced on ascending to great heights in mountainous districts, where the pressure of the atmosphere is light, and the air much rarified or expanded, the breathing becoming difficult and laborious. Travellers, and even the most practised guides, frequently fall down suddenly, as if struck with lightning, when approaching lofty summits, chiefly on account of the thinness of the air which they are breathing, and some minutes elapse before they recover.

In the elevated plains of South America, the inhabitants have larger chests than those of the lower regions; an admirable instance of the animal frame adapting itself to the circumstances in which it is placed.

At lofty elevations, where the atmospheric pressure is light, an expansion of the blood-vessels and muscles of the human body takes place, owing to the removal of the ordinary pressure. At great heights, the air in the human body has sometimes become so much expanded as to force the blood from the pores, as though the individual had been cupped all over.

Measuring of Heights by the Barometer.—Although the barometer does not enable us to measure the exact height of the atmosphere, yet it is of great service in assisting our measurement of heights within certain limits, or at different degrees of elevation in the atmosphere. The pressure of the air decreasing as we rise in the atmosphere, the mercury necessarily falls in the barometer according to a law which has been calculated and reduced to tables; and, having these tables of the fall of the mercury, we can ascertain the height of the mountain by the height of the column of mercury in the barometer.

The mercury in the barometer falls 1-10th of an inch for every 87 feet of ascent. This number is not rigidly exact, but sufficient for common purposes. Hence, if a barometer, whose mercurial column stood at 30 inches, were taken up to the top of St. Paul's, London, a height of 404 feet, the mercury would fall to about 29 3-5 inches. Again, if we ascend to the top of a high hill, and take a barometer with us, and find that the mercury has descended in the tube 1½ inches, we may conclude that the hill is 1305 feet in perpendicular height.

De Luc's barometer fell to 12 inches when he was at the height of 20,000 feet in his balloon.

On Aeronautics or Air-Navigation.—The notion of the possibility of raising a man or a machine in the air, was very widely disseminated in the ancient world; but, till the year 1783, no rational principle appears to have been conceived, by means of which this idea could be practically acted upon. Flying by means of artificial wings was long thought of, and, notwithstanding the conclusive arguments brought against it, there are still persons who are foolish enough to maintain the probability of its being accomplished; whilst the religious and profane historians of every nation have recorded instances of persons being carried through the air, both by the agency of spirits and mechanical inventions.

In the year 1783 the discovery of the art of ærostation was all at once announced, in France. Two brothers, Stephen and John Montgolfier, natives of Annonay, and masters of a considerable paper manufactory there, constructed and raised the first balloon into the atmosphere. The idea was suggested by observing the natural ascent of smoke and clouds, and their design was to form an artificial cloud, by enclosing the smoke in a paper bag, and making it carry up the bag along with it. They, therefore, burnt straw under the aperture of a balloon or paper ball, and the rarified air passing into it, raised it to the ceiling. On repeating the experiment in the open air, it rose to the height of about seventy feet.

Soon after this, one of the brothers arrived at Paris, where he was invited by the Academy of Sciences to repeat his experiment at their expense. Accordingly, he constructed a large balloon of an elliptical form; the usual success attended the exhibition, the machine swelled and rose, charged with between four and five hundred weight.

On the 19th of September, 1783, this experiment was repeated before the king and court at Versailles, with a balloon 60 feet high, and 43 feet in diameter, painted with water colors, and finely decorated. Along with this machine was sent a wicker cage, containing a sheep, a cock and a duck, the first ærial voyagers, who were sent up, *without leave asked!* All came down safe, with the exception of the last, whose wing was hurt, "But this," says M. de St. Fond, jealous for the honor of the balloon, "was done by a kick received from the sheep, half an hour before the ascent, in the presence of ten witnesses;" he also assures his readers, that they may safely discredit the rumor that the cock had broken his head, and he adds, "it is vexatious to see the public papers thus assert things without proof, which, in such cases, ought always to be guaranteed by the signatures of those who send them." This machine rose to the height of about 1,440 feet, and, after remaining in the air about eight minutes, fell to the ground, at the distance of 10,200 feet. Machines constructed of paper, and raised into the atmosphere in this manner, on the prin-

ciple of the rarefaction of common air, by heat, were called Montgolfiers, after the name of their inventor, to distinguish them from the hydrogen balloons, which were made immediately afterwards.

The first persons who offered to leave the earth entirely, were the Marquis d'Arlandes and M. Pilatre de Rosier; and they performed this feat at the Chateau de la Muette, near Passy, November 21, 1783, in a Montgolfier. They met with no inconvenience during the voyage, which lasted about 25 minutes, during which time they had passed over a space of about five miles. From the account given of the voyage by the Marquis d'Arlandes, it appears that they met with several different currents of air, the effect of which was to give a very sensible shock to the machine, and that they were in some danger of having the balloon burnt altogether, as the Marquis observed several holes made by the fire in the lower part of it, which alarmed him considerably. However, the progress of the fire was easily stopped by the application of a wet sponge, and all appearance of danger ceased. This voyage of M. Pilatre and the Marquis d'Arlandes may be said to conclude the history of those ærostatic machines which were raised by fire.

At the same period that the original discoverers of ærostation were thus astonishing France, the lightness of hydrogen gas was discovered, and Messrs. Charles and Roberts resolved to employ it in the inflation of a balloon. On the 1st of December, 1783, these gentlemen ascended from the Tuilleries, in a hydrogen of 26 feet in diameter, made a most successful voyage, and descended in perfect safety, at a distance of 27 miles from Paris; persons skilled in mathematics being conveniently situated to observe the height, velocity, &c., of the balloon. After coming down, Mr. Charles re-ascended alone. At his departure the sun was set in the valleys, but on attaining an elevation of about 9,000 feet, the sun again became visible. He says, "I was the only illuminated object, all the rest of nature being plunged in shadow." In a little time afterwards he pulled the valve, and accelerated his descent. When within two or three hundred feet of the earth, he threw out two or three pounds of ballast, which rendered the balloon again stationary, and, soon after, he gently alighted in a field, about three miles distant from the place where he re-ascended.

March 2, 1784, M. Blanchard made his first ascent from Paris, in a hydrogen balloon. He added wings and a rudder, but found that they were useless.

All these ascents had hitherto been conducted with the most perfect safety; but, on the 15th of June, 1785, the enterprising Rosier, and his friend Romain, after ascending to a height of above 3000 feet, were precipitated to the ground, and dashed to pieces, in consequence of their balloon taking fire. Among the greatest dangers to which æronauts are exposed, is that of a too rapid and premature descent. To guard against such accidents, M. Blanchard constructed the parachute or open umbrella, by means of which the æronaut, in case of his balloon sustaining injury, can safely desert it in mid-air, and drop, without sustaining harm, to the ground. During an excursion which he undertook from Lisle, about the end of August, 1785, and in which he traversed a distance of not less than 300 miles, M. Blanchard let down a dog, from a vast height, in the basket attached to a parachute, and the animal falling gently through the air, reached the ground unhurt.

Since that period the practice and management of the parachute has been carried much further by other æronauts, and particularly by M. Garnerin, who has repeatedly descended by this machine from the region of the clouds.

September 21st, 1802, M. Garnerin descended successfully from a balloon by means of a parachute, near the small-pox hospital, St. Pancras, London. The height from which he descended was so great, that he could scarcely be distinguished. "At first," namely, before the parachute opened, "he fell with a great velocity, but as soon as it was fully expanded, his descent became very gradual and gentle."

Three voyages have been undertaken since the commencement of the present century, for purposes professedly scientific. In 1804, M. Guy Lussac and A. Biot ascended, at Paris, to a height of 13,000 feet, provided with a suitable philosophical apparatus. During the same year, M. Guy Lussac ascended, alone, to an elevation of 23,000 feet above the sea level, which is the greatest altitude above the earth's surface ever attained. Hundreds of ascents have been made since this period, but without giving rise to any novelties worth relating; indeed, ballooning has become a popular amusement, and æronauts employ their experience as a means of private gain and public exhibition.

Although, originally great expectations were entertained of ærostation, hitherto the discovery has yielded little practical benefit. The balloon is now a toy in which ascents are made to amuse a crowd; that which was honorable risk so long as anything could be gained to science, is now mere fool-hardiness, and will continue to be so until some definite object is proposed, and some probable means of attaining it is suggested.
